

Clinical and Stone-related Factors Influencing Stone-free Status After Retrograde Intrarenal Surgery

© Kadir Böcü¹, © Doğucan Nuri Uğur¹, © Nurullah Altınkaya¹, © Ali Furkan Batur²

¹Niğde Ömer Halisdemir Training and Research Hospital, Clinic of Urology, Niğde, Türkiye

²Selçuk University Faculty of Medicine, Department of Urology, Konya, Türkiye

What's known on the subject? and What does the study add?

Stone size and lower-pole location are commonly linked to residual fragments after RIRS, but the predictive values of Hounsfield unit (HU) density, body mass index (BMI), American Society of Anesthesiologists (ASA) class, and preoperative stenting remain inconsistent. Using a computed tomography-based stone-free definition in a large single-center cohort (n=527) and multivariable logistic regression including discrimination and calibration assessment, we found that stone size, lower-pole location, stone multiplicity, and age independently predicted stone-free status, whereas HU density, BMI, ASA class, and preoperative stenting did not (area under the curve 0.839).

Abstract

Objective: To evaluate clinical and stone-related factors associated with stone-free status after retrograde intrarenal surgery (RIRS) and to identify independent predictors of postoperative success.

Materials and Methods: We retrospectively reviewed adult patients who underwent RIRS for renal calculi from January 2020 to December 2025. Stone-free status was defined as no stones or clinically insignificant residual fragments (≤ 4 mm) on postoperative computed tomography at 3 months. Groups were compared using the Mann-Whitney U test and the chi-square test. Univariate and multivariable logistic regression analyses were performed. Model discrimination and calibration were assessed using the area under the receiver operating characteristic curve (AUC) and the Hosmer-Lemeshow test.

Results: Among 527 patients, 332 (63.0%) were stone-free. In multivariable analysis, larger maximum stone size [odds ratio (OR): 0.80 per mm], lower-pole location (OR: 0.21), stone multiplicity (OR: 0.59), and older age (OR: 0.98 per year) were independently associated with reduced odds of being stone-free. In contrast, body mass index (BMI), stone density [Hounsfield unit (HU)], American Society of Anesthesiologists (ASA) class, and preoperative stenting were not statistically significant. The model showed excellent discrimination (AUC: 0.839) and good calibration (Hosmer-Lemeshow $p=0.77$).

Conclusion: In contemporary practice, stone burden, lower-pole location, multiplicity, and age were the main determinants of stone-free status after RIRS; HU density, ASA class, BMI, and routine preoperative stenting were not predictive.

Keywords: Urolithiasis, retrograde intrarenal surgery, stone-free status, predictive factors, flexible ureteroscopy

Introduction

Renal stone disease is a prevalent and growing global health problem, driven by lifestyle, metabolic, and environmental factors (1). Retrograde intrarenal surgery (RIRS) is a widely used minimally invasive option for the management of renal calculi, supported by advances in flexible ureteroscope technology, high-power laser systems, and endourological technique (2).

As indications have expanded to more complex stone burdens, reported stone-free outcomes still vary considerably across centers and populations (3,4), highlighting the need to better define factors that influence procedural success (4).

Multiple predictors of RIRS outcomes have been proposed, including stone size, anatomical location, stone multiplicity, Hounsfield unit (HU) density, and preoperative ureteral stenting

Correspondence: Kadir Böcü MD, Niğde Ömer Halisdemir Training and Research Hospital, Clinic of Urology, Niğde, Türkiye

E-mail: kadirbocu@ohu.edu.tr, drkadirbocu@gmail.com **ORCID-ID:** orcid.org/0000-0003-4323-4037

Received: 02.01.2026 **Accepted:** 09.03.2026 **Epub:** 14.10.2026

Cite this article as: Böcü K, Uğur DN, Altınkaya N, Batur AF. Clinical and stone-related factors influencing stone-free status after retrograde intrarenal surgery. J Urol Surg. [Epub Ahead of Print]



(5-8). However, prior evidence is often limited by small sample sizes, heterogeneous imaging modalities and follow-up, and inconsistent definitions of stone-free status. While stone size and lower-pole anatomy demonstrate relatively consistent relevance, findings for HU density, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and preoperative stenting remain conflicting across studies (9,10). These inconsistencies complicate preoperative counseling and hinder optimal patient selection and surgical planning.

In addition, relatively few studies have evaluated a broad range of demographic, anatomical, and radiologic predictors within a single multivariable framework (11). Reporting model performance using discrimination and calibration metrics is increasingly recommended in clinical prediction research (12), yet remains inconsistent in the RIRS literature. Consequently, clinicians have few high-quality estimates of the probability of being stone-free following RIRS.

Therefore, we evaluated a large contemporary cohort of adults undergoing RIRS using a standardized computed tomography (CT)-based definition of stone-free status (≤ 4 mm residual fragments). We aimed to identify independent clinical and stone-related predictors of stone-free status using univariate and multivariable logistic regression and to report model discrimination and calibration.

Materials and Methods

Study Design and Setting

This retrospective observational study included adult patients who underwent RIRS for renal calculi at Niğde Ömer Halisdemir Training and Research Hospital, a tertiary referral urology center, between January 2020 and December 2025. Four experienced endourologists performed all procedures in accordance with standardized institutional practice.

Patient Selection and Data Collection

Electronic hospital records were reviewed to identify all consecutive RIRS procedures performed during the study period. To avoid correlated observations, only the index (first) RIRS procedure for each patient was included; therefore, each patient contributed a single renal unit. Demographic and clinical variables included age, sex, BMI, ASA class, stone laterality, preoperative ureteral stenting, and perioperative details. Stone characteristics, including location, number of stones, maximum diameter, and mean attenuation in HU, were obtained from preoperative CT images and reports. For patients with multiple stones, the maximum stone diameter was defined as the maximum diameter of the largest stone. Stone multiplicity was defined as the presence of ≥ 2 stones on preoperative CT. Lower-pole location was defined as the presence of at least one stone

in the lower calyx, irrespective of additional stone sites. Stone burden was quantified using the maximum stone diameter, as it was the most consistently available measurement in radiology reports; cumulative diameter or volumetric measures were not available for all patients.

All patients underwent preoperative non-contrast CT as part of routine stone evaluation. Stone attenuation (HU) was recorded as the mean HU measured within a region of interest placed in the stone on axial images at the level of the stone's maximal diameter, avoiding partial-volume effects and obvious artifacts where possible. CT acquisition parameters followed routine clinical protocols during the study period and may have varied modestly across scanners and years.

RIRS was performed under general anesthesia using flexible ureteroscopy with laser lithotripsy. The use of a ureteral access sheath, the choice between dusting and fragmentation with basket extraction, and postoperative ureteral stent placement followed surgeon preference within standardized institutional practice.

Outcome Definition

The primary outcome was stone-free status, defined as no residual calculi or only clinically insignificant residual fragments measuring ≤ 4 mm on postoperative CT performed 3 months after surgery. Patients were classified into stone-free and residual-fragment groups.

Statistical Analysis

Continuous variables were summarized as medians with interquartile ranges (IQRs), and categorical variables as frequencies and percentages. Between-group comparisons were performed using the Mann-Whitney U test for continuous variables and the chi-square test for categorical variables.

Univariate logistic regression analyses were performed to screen for associations with stone-free status. Variables with clinical relevance or a univariate p-value < 0.10 were entered into a multivariable logistic regression model. The multivariable model included age, BMI, maximum stone size, stone multiplicity, lower-pole location, stone density (HU), ASA class (modeled as an ordinal variable), and preoperative ureteral stenting. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

Model performance was evaluated using measures of discrimination and calibration. Discrimination was assessed with the area under the receiver operating characteristic (ROC) curve (AUC). Calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test and a decile-based calibration plot. Because this was a single-cohort retrospective study, the performance metrics represent apparent (in-sample) performance. Statistical

significance was set at $p < 0.05$. All analyses were performed using Python (Python Software Foundation, Beaverton, OR, USA) with the SciPy and statsmodels libraries.

Results

Patient and Stone Characteristics

A total of 527 patients were included in this analysis. Of these, 332 patients (63.0%) achieved stone-free status after RIRS, whereas 195 patients (37.0%) had residual fragments.

Patients in the stone-free group were younger (median age, 49.0 years, IQR: 39.8-61.0 vs. 56.0 years, IQR: 45.0-65.5; $p < 0.001$). BMI was similar between the groups (27.0 vs. 26.9 kg/m²; $p = 0.633$).

Maximum stone diameter was smaller in stone-free patients than in those with residual fragments (10.0 mm, IQR: 8.0-15.0 vs. 19.0 mm, IQR: 12.2-20.0; $p < 0.001$). Sex distribution (59.8% vs. 60.4% male; $p = 0.967$), preoperative stenting (23.6% vs. 25.3%; $p = 0.740$), and ASA class distribution ($p = 0.768$) did not differ between groups (Table 1).

Stone density did not differ between groups (median 1070 HU, IQR: 780-1450 vs. 1050 HU, IQR: 800-1435; $p = 0.691$). The boxplots showed substantial overlap, suggesting that HU density alone did not discriminate stone-free status (Figure 1).

Lower-pole stones were more common in patients with residual fragments than in stone-free patients (62.6% vs. 43.1%; $p < 0.001$). Upper- and mid-pole locations were more frequent among stone-free patients (Figure 2).

Univariate Predictors of Stone-Free Status

Univariate logistic regression identified several variables associated with stone-free status. Increasing age was associated with lower odds of stone-free outcome (OR: 0.98; 95% CI: 0.97-0.99; $p = 0.0016$). Maximum stone size showed a strong inverse association: each 1-mm increase in stone size was associated

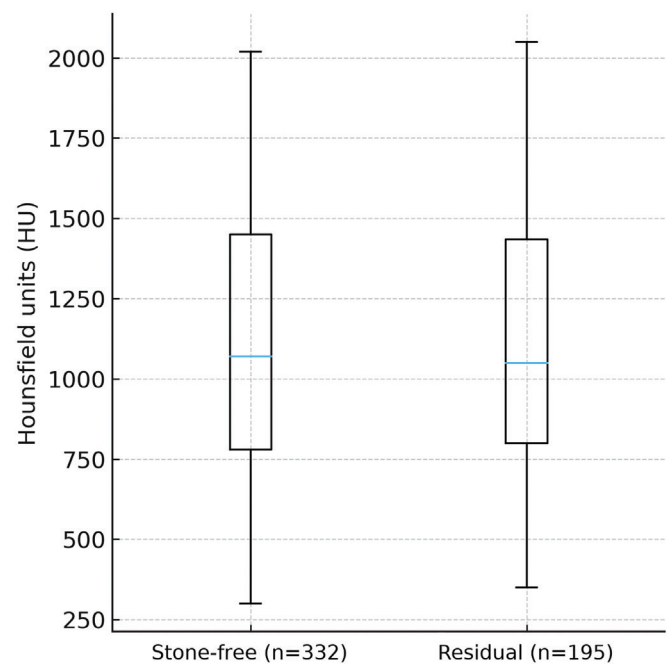


Figure 1. Stone density distribution. Boxplot comparison of stone density between stone-free (n=332) and residual-fragment (n=195) groups, showing medians and interquartile ranges

with lower odds of stone-free status (OR: 0.83; 95% CI: 0.80-0.87; $p < 0.001$). Patients with multiple stones had lower odds of being stone-free (OR: 0.54; 95% CI: 0.36-0.82; $p = 0.0038$).

Lower-pole location was also associated with reduced stone-free odds (OR: 0.43; 95% CI: 0.29-0.63; $p < 0.001$). Stone density (HU), BMI, ASA class, sex, and preoperative ureteral stenting were not significantly associated with stone-free status (all $p > 0.05$) (Figure 3).

Multivariable Predictors of Stone-Free Status

In the multivariable logistic regression model, maximum stone size remained independently associated with lower stone-free odds (OR: 0.80; 95% CI: 0.76-0.84; $p < 0.001$), as did lower-pole

Table 1. Baseline demographic and stone-related characteristics according to stone-free status

Variable	Stone-free (n=332)	Residual (n=195)	p-value
Age (years)	49.0 (39.8-61.0)	56.0 (45.0-65.5)	<0.001
BMI (kg/m ²)	27.0 (24.6-30.4)	26.9 (24.3-30.1)	0.633
Maximum stone size (mm)	10.0 (8.0-15.0)	19.0 (12.2-20.0)	<0.001
Stone density (HU)	1070 (780-1450)	1050 (800-1435)	0.691
Male sex, n (%)	195 (59.8%)	116 (60.4%)	0.967
Multiple stones, n (%)	79 (23.8%)	68 (34.9%)	0.008
Lower-pole location, n (%)	143 (43.1%)	122 (62.6%)	<0.001
Preoperative ureteral stent, n (%)	78 (23.6%)	49 (25.3%)	0.740
ASA class distribution	ASA 1: 36; ASA 2: 259; ASA 3: 37	ASA 1: 25; ASA 2: 147; ASA 3: 21	0.768

Values are presented as median (IQR) or number (percentage). p-values calculated using Mann-Whitney U or chi-square tests as appropriate
ASA: American Society of Anesthesiologists, BMI: Body mass index, IQR: Interquartile range, HU: Hounsfield unit

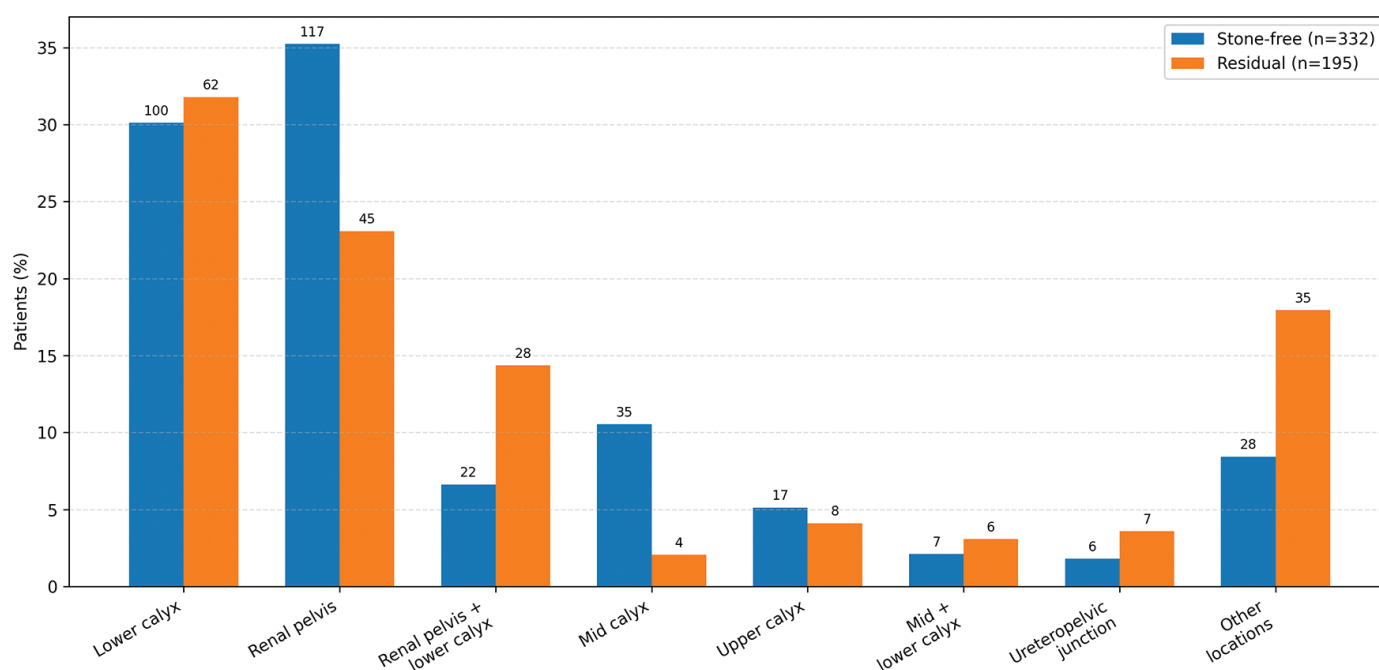


Figure 2. Stone localization distribution. Distribution of stone localization categories in stone-free (n=332) and residual-fragment (n=195) groups. Bars show within-group percentages; numbers above bars indicate patient counts. “Other locations” includes less frequent multi-location categories

location (OR: 0.21; 95% CI: 0.12-0.37; $p < 0.001$). Stone multiplicity (OR: 0.59; 95% CI: 0.35-0.99; $p = 0.047$) and age (OR: 0.98; 95% CI: 0.96-1.00; $p = 0.026$) also retained independent associations. BMI, stone density, ASA class, and preoperative stenting were not independently associated with stone-free status (Figure 4).

Model Performance

The multivariable model demonstrated excellent discrimination (AUC: 0.839) on ROC analysis (Figure 5). Calibration showed close agreement between predicted and observed stone-free probabilities across deciles, with a non-significant Hosmer-Lemeshow test ($p = 0.77$) (Figure 6).

Discussion

In this contemporary single-center cohort, larger stone size, stone multiplicity, lower-pole location, and older age were independently associated with lower odds of achieving stone-free status after RIRS. These findings are consistent with prior endourological literature and support the continued importance of stone burden and unfavorable intrarenal location as key determinants of RIRS outcomes (13-15).

The inverse association between stone size and stone-free status likely reflects increased operative complexity with greater stone burden, including longer operative time, reduced visualization, and the need to manage a larger number of fragments (16).

Similarly, lower-pole stones are technically more challenging because of limitations in scope deflection, more acute infundibulopelvic angles, and less favorable fragment clearance dynamics (17).

Stone multiplicity remained independently associated with lower stone-free odds, which may reflect cumulative stone burden and the need to access multiple calyces (18). In contrast, HU density, ASA class, BMI, and preoperative stenting were not independently predictive in our model. The overlap in HU distributions suggests that attenuation alone may be insufficient to capture intraoperative fragmentation behavior in the modern RIRS setting; improvements in laser systems and dusting techniques may attenuate the practical impact of hardness (19). We also did not observe an independent association of routine preoperative stenting with stone-free status, consistent with recent studies questioning its routine use in uncomplicated cases (20).

Current RIRS Scoring Systems in Context

Several scoring systems, including the Resorlu-Unsal, R.I.R.S., and modified S-ReSC scores, have been developed to estimate stone-free outcomes by integrating radiologic and anatomical parameters (21-23). However, their clinical performance has been variable, often constrained by heterogeneous stone-free definitions and reliance on measurements subject to inter-observer variability (24).

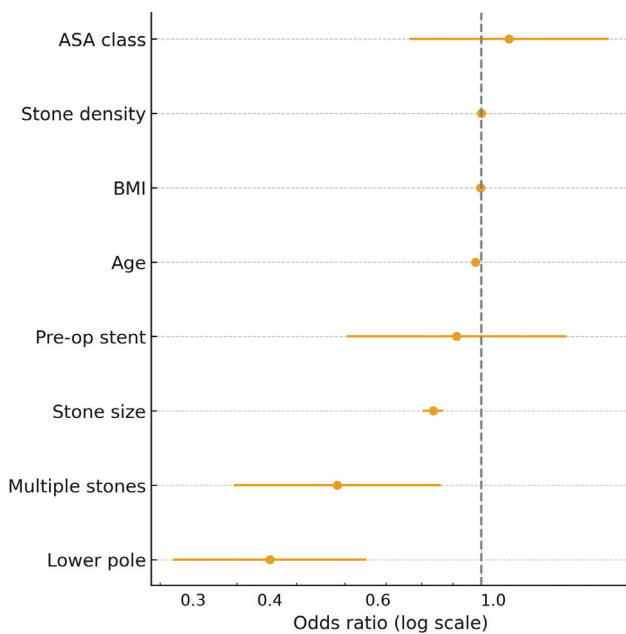


Figure 3. Univariate predictors of stone-free status. Forest plot showing univariate logistic regression odds ratios with 95% confidence intervals for candidate predictors of stone-free status. Continuous variables are modeled per 1 unit (age per year, BMI per kg/m², stone size per mm, stone density per HU); categorical variables are coded as yes/no, and ASA class is modeled as an ordinal variable

BMI: Body mass index, HU: Hounsfield unit, ASA: American Society of Anesthesiologists

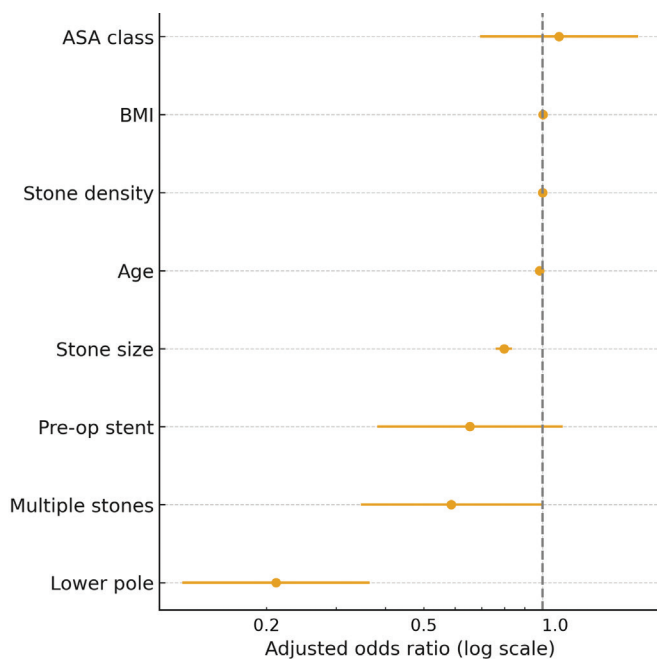


Figure 4. Multivariable predictors of stone-free status. Forest plot showing adjusted odds ratios and 95% confidence intervals for variables included in the multivariable logistic regression model. Continuous variables are modeled per 1 unit (age per year, BMI per kg/m², stone size per mm, stone density per HU); categorical variables are coded as yes/no, and ASA class is modeled as an ordinal variable

BMI: Body mass index, HU: Hounsfield unit, ASA: American Society of Anesthesiologists

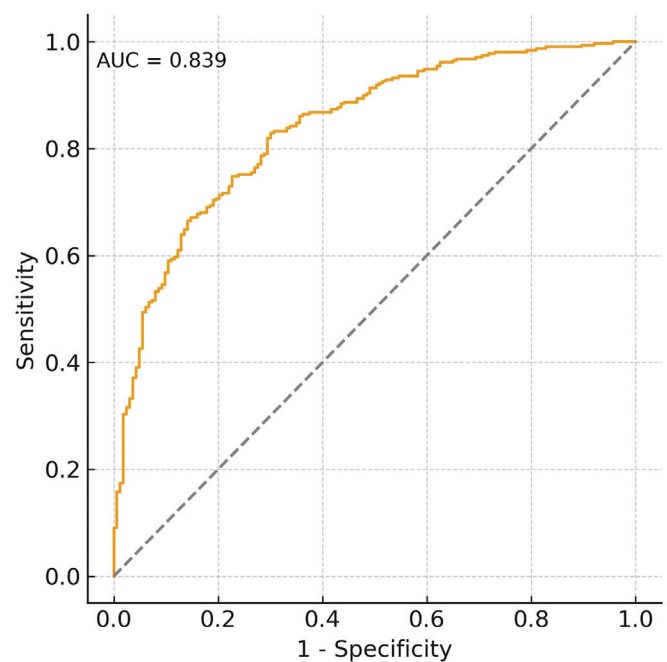


Figure 5. ROC curve for predictive model. ROC curve demonstrating discrimination of the multivariable model (AUC: 0.839)

AUC: Area under the curve, ROC: Receiver operating characteristic

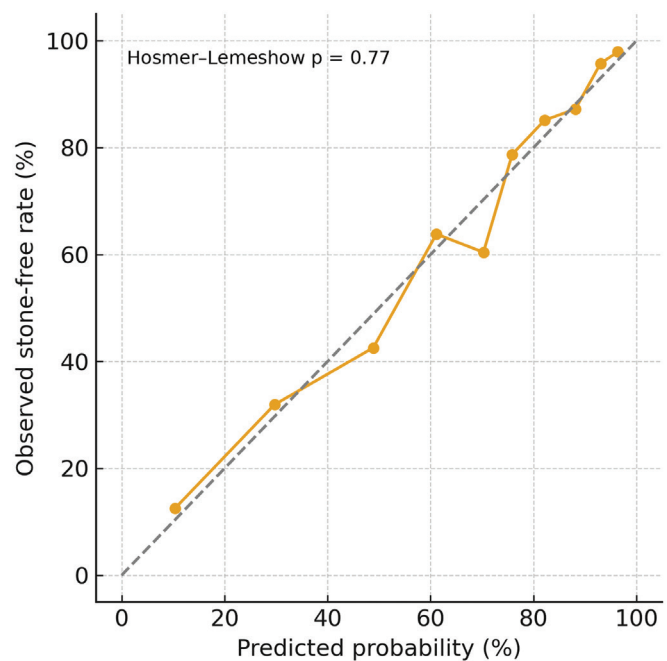


Figure 6. Calibration plot of predictive model. Calibration plot comparing predicted and observed stone-free probabilities across deciles (Hosmer-Lemeshow p=0.77)

Maximum stone size, lower-pole location, stone multiplicity, and age were independently associated with stone-free status in the full multivariable model, which had an apparent AUC of 0.839. These results may inform refinement of existing scoring systems by prioritizing variables with consistent predictive value in contemporary practice (25).

Clinical Implications

These results have practical implications. Preoperative CT-based stone mapping is particularly important in patients with larger, multiple, or lower-pole stones, who may benefit from counseling regarding residual fragments and the possibility of staged treatment. In addition, the limited predictive value in our model of HU density and routine preoperative stenting may help guide counseling and resource use.

Study Limitations

This retrospective, single-center design introduces potential selection bias and may limit generalizability to institutions with different case mix, levels of experience, or equipment. Important anatomical measurements, such as infundibulopelvic angle, infundibular width, and calyceal length, were not quantified. Operative factors (e.g., laser settings, scope characteristics, irrigation parameters) were also not assessed. Model performance was evaluated in-sample, and external validation is required to confirm applicability across settings. Stone burden was represented by maximum diameter rather than by cumulative diameter or by volumetric measures, which may better capture the total burden in patients with multiple stones.

Despite these limitations, the large sample size, standardized outcome definitions, and rigorous analytical methods provide a solid foundation for interpreting our findings. Prospective multicenter studies incorporating 3-dimensional anatomic reconstructions, laser-specific metrics, and external validation are needed to further refine predictive frameworks for RIRS.

Conclusion

In this comprehensive evaluation of the predictors of stone-free status following RIRS, maximum stone size, stone multiplicity, lower pole location, and patient age emerged as the most critical independent determinants of postoperative clearance. Conversely, HU density, ASA class, BMI, and preoperative stenting were not independently associated with stone-free status in this cohort. These findings refine our understanding of the relative importance of key predictive factors, challenge assumptions of several existing scoring systems, and support the development of simplified, evidence-based models to enhance preoperative risk stratification and clinical decision-making.

Ethics

Ethics Committee Approval: This study was approved by the Niğde Ömer Halisdemir University Non-Interventional Clinical Researches Ethics Committee (approval no: 2025/142, date: 27.12.2025).

Informed Consent: Written informed consent was waived due to the study's retrospective design.

Acknowledgments

The authors thank the Niğde Ömer Halisdemir Training and Research Hospital Urology Clinic staff for their assistance in patient care and data collection.

Footnotes

Authorship Contributions

Surgical and Medical Practices: K.B., D.N.U., N.A., Concept: K.B., Design: K.B., Data Collection or Processing: K.B., D.N.U., N.A., Analysis or Interpretation: K.B., D.N.U., A.F.B., Literature Search: K.B., D.N.U., N.A., A.F.B., Writing: K.B., A.F.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Yao W, Wei X, Jing Q, Yuan X, Liu F, Zhang X. Epidemiological trends of urolithiasis in working-age populations: findings from the global burden of disease study 1990-2021. *PLoS One*. 2025;20:e0327343. [\[Crossref\]](#)
2. Yu S, Liu L, Li Y, Zhou L, Chen J, Li H, Wang K. Flexible ureteroscopic treatment of kidney stones: how do the new laser systems change our concepts? *Asian J Urol*. 2024;11:156-168. [\[Crossref\]](#)
3. Juliebø-Jones P, Gauhar V, Lim EJ, Traxer O, Madarriaga YQ, Castellani D, Fong KY, Bujons A, Ragoori D, Shrestha A, Vaddi CM, Bhatia TP, Sekerci CA, Tanidir Y, Teoh JY, Somani BK. Outcomes and considerations for retrograde intrarenal surgery (RIRS) in the setting of multiple and large renal stones (>15 mm) in children: findings from multicentre and real-world setting. *BJUI Compass*. 2024;5:558-563. Erratum in: *BJUI Compass*. 2024;5:1324-1329. [\[Crossref\]](#)
4. Kayar K, Kayar R, Tuncel KG, Tosun C, Yucebas OE. Stone-free rate after RIRS: a multivariable analysis and predictive nomogram from a single-center study. *World J Urol*. 2025;43:369. [\[Crossref\]](#)
5. Raj K K, Adiga K P, Chandni Clara D'souza R, B N, Shetty M. Assessment of factors responsible for stone-free status after retrograde intrarenal surgery. *Cureus*. 2024;16:e63627. [\[Crossref\]](#)
6. Ergani B, Kozacıoğlu Z. Effects of three-dimensional measurement of the urinary stone size on the surgical outcomes of retrograde intrarenal stone surgery. *J Urol Surg*. 2021;8:111-117. [\[Crossref\]](#)
7. Yuk HD, Park J, Cho SY, Sung LH, Jeong CW. The effect of preoperative ureteral stenting in retrograde intrarenal surgery: a multicenter, propensity score-matched study. *BMC Urol*. 2020;20:147. [\[Crossref\]](#)

8. Akdeniz E, Ulubay M. The impact of Hounsfield unit-related variables on retrograde intrarenal surgery outcomes in isolated lower pole kidney stones. *Med Bull Haseki*. 2023;61:193-198. [\[Crossref\]](#)
9. Elmoahady BN, Farag MM, Sherif HW, El Ghobashy A, Al Hefnawy MA. Predicting stone free rate after retrograde intrarenal surgery using RIRS scoring system versus Resorlu Unsal stone score (RUSS). *Arab J Urol*. 2023;22:102-108. [\[Crossref\]](#)
10. Polat S, Danacioglu YO, Yarimoglu S, Soytas M, Erdogan A, Teke K, Degirmenci T, Tasci AI. External validation of the current scoring systems and derivation of a novel scoring system to predict stone free rates after retrograde intrarenal surgery in patients with cumulative stone diameter of 2-4 cm. *Actas Urol Esp (Engl Ed)*. 2023;47:211-220. English, Spanish. [\[Crossref\]](#)
11. Lee HY, Tung YH, Elises JC, Wang YC, Gauhar V, Cho SY. Machine learning-based prediction of stone-free rate after retrograde intrarenal surgery for lower pole renal stones. *World J Urol*. 2025;43:433. [\[Crossref\]](#)
12. Xun Y, Chen M, Liang P, Tripathi P, Deng H, Zhou Z, Xie Q, Li C, Wang S, Li Z, Hu D, Kamel I. A novel clinical-radiomics model pre-operatively predicted the stone-free rate of flexible ureteroscopy strategy in kidney stone patients. *Front Med (Lausanne)*. 2020;7:576925. [\[Crossref\]](#)
13. Boudreau R, Fathy M, Hodhod A, Siddiqui R, Alaradi H, Alhelal S, Abbas L, Alaref A, Zakaria AS, Elmansy H. Factors predicting stone-free rates after retrograde intrarenal surgery for lower pole kidney stones a single-center, retrospective analysis. *Can Urol Assoc J*. 2024;18:399-404. [\[Crossref\]](#)
14. Zaza MMA, Tawfeek AM, Salem TAE, Soliman MIS, Hassan Ali M. Risk factors of stone residual after retrograde intrarenal surgery: a prospective cohort study. *Urologia*. 2024;91:550-557. [\[Crossref\]](#)
15. Tastemur S, Senel S, Kizilkan Y, Ozden C. Evaluation of the anatomical factors affecting the success of retrograde intrarenal surgery for isolated lower pole kidney stones. *Urolithiasis*. 2022;50:65-70. [\[Crossref\]](#)
16. Tonyalı Ş, Yılmaz M, Karaaslan M, Ceylan C, Işııkay L. Prediction of stone-free status after single-session retrograde intrarenal surgery for renal stones. *Türk J Urol*. 2018;44:473-477. [\[Crossref\]](#)
17. Zeng G, Traxer O, Zhong W, Osther P, Pearle MS, Preminger GM, Mazzone G, Seitz C, Geavlete P, Fiori C, Ghani KR, Chew BH, Git KA, Vicentini FC, Papatsoris A, Brehmer M, Martinez JL, Cheng J, Cheng F, Gao X, Gadzhiev N, Pietropaolo A, Proietti S, Ye Z, Sarica K. International Alliance of Urolithiasis guideline on retrograde intrarenal surgery. *BJU Int*. 2023;131:153-164. [\[Crossref\]](#)
18. Özman O, Başataç C, Akgül HM, Çınar Ö, Sancak EB, Yazıcı CM, et al. Prediction of possible factors that affect stone-free rate of retrograde intrarenal surgery: a multicenter study. *Namik Kemal Med J*. 2020;8:398-403. [\[Crossref\]](#)
19. Wen Z, Wang L, Liu Y, Huang J, Chen CX, Wang CJ, Chen LL, Yang XS. A systematic review and meta-analysis of outcomes between dusting and fragmentation in retrograde intrarenal surgery. *BMC Urol*. 2023;23:113. [\[Crossref\]](#)
20. Jeong JY, Cho KS, Jun DY, Moon YJ, Kang DH, Jung HD, Lee JY. Impact of preoperative ureteral stenting in retrograde intrarenal surgery for urolithiasis. *Medicina (Kaunas)*. 2023;59:744. [\[Crossref\]](#)
21. Resorlu B, Unsal A, Gulec H, Oztuna D. A new scoring system for predicting stone-free rate after retrograde intrarenal surgery: the "Resorlu-Unsal stone score". *Urology*. 2012;80:512-518. [\[Crossref\]](#)
22. Xiao Y, Li D, Chen L, Xu Y, Zhang D, Shao Y, Lu J. The R.I.R.S. scoring system: an innovative scoring system for predicting stone-free rate following retrograde intrarenal surgery. *BMC Urol*. 2017;17:105. [\[Crossref\]](#)
23. Jung JW, Lee BK, Park YH, Lee S, Jeong SJ, Lee SE, Jeong CW. Modified Seoul National University Renal Stone Complexity score for retrograde intrarenal surgery. *Urolithiasis*. 2014;42:335-340. [\[Crossref\]](#)
24. Özman O, Akgül HM, Başataç C, Sancak EB, Çınar Ö, Çakır H, Yazıcı CM, Akpınar H, Önal B; RIRSearch Study Group. Recent scoring systems predicting stone-free status after retrograde intrarenal surgery; a systematic review and meta-analysis. *Cent European J Urol*. 2022;75:72-80. [\[Crossref\]](#)
25. Bozkurt IH, Karakoyunlu AN, Koras O, Celik S, Sefik E, Cakici MC, Degirmenci T, Imamoglu MA. External validation and comparison of current scoring systems in retrograde intrarenal surgery: multi-institutional study with 949 patients. *Int J Clin Pract*. 2021;75:e14097. [\[Crossref\]](#)